VOL. XXIV. August, 1897. No 8.

THE
Journal
OF
Nervous and Mental Disease

AMERICAN NEUROLOGICAL ASSOCIATION.

Twenty-third Annual Meeting, held at St. John's Parish Hall, Washington, D.C., May 4th, 5th, and 6th, 1897.

The President, Dr. M. A. Starr, in the chair.

Session of May 4th.

President's Address,

THE TRANSMISSION OF SENSATIONS THROUGH THE SPINAL CORD.

By PROF. M. ALLEN STARR, M.D., Ph.D.

Gentlemen:—

In taking the Chair to preside over this meeting, I feel that I must first express to you my thanks for the honor you have done me in choosing me as your chairman, an honor which I fully appreciate as I read over the list of names of my predecessors in office—men who have made American neurology respected in every land. I trust that you will aid me in this meeting in maintaining the high standard of our discussions, and thus secure the success of the twenty-third annual meeting of this society.

The subject which I wish to present to you this morning is the transmission of sensory impulses through the spinal cord, a subject which is still extremely obscure and by no means as yet accurately determined. I think that the conclusions derived from physiological experiments upon the lower animals are open to grave criticism, first, because of the fact that the majority of such experiments performed years ago were done without antiseptic precautions, and were attended by secondary septic inflammations of the cord and its meninges, which invalidated the conclusions drawn from them; and secondly, because of the great variation in the anatomical structure of the cords of the lower animals and of man. It seems, therefore, necessary to rely almost entirely upon pathology for the data in determining the facts.

While recent investigations have abundantly confirmed the general results long known as ascending degeneration in the spinal cord after lesions of the nerve roots and after lesions of a transverse nature, the recent methods of investigation, especially the staining methods of Weigert, Van Gieson, and of Marchi, have furnished some interesting results. Everyone who has studied the degeneration process in the cord has been aware of the fact that in a degenerated tract there are always found many healthy nerve fibres, but it was due to Marie that this mixed character of the various columns of the cord was first definitely brought to our notice, and his results have been abundantly confirmed by the investigations with the aid of the Marchi method. It is no longer possible to speak of the columns of the spinal cord as being exclusively ascending or descending in the direction of their fibres. We know now that all columns of the cord contain fibres of greater or less extent passing both upward and downward, and that mingled among these fibres there are very many others whose function is purely associative between the various segments. Even in the long pyramidal and anterior median descending motor columns of the cord there are very numerous ascending fibres, and in the posterior columns, long supposed to be ascending only, we now distinguish the descending comma-shaped columns of Schultze, the descending posterior marginal columns of Flechsig, and the association fibres entering the limiting layer along the gray matter of the posterior commissure. Recent investigations by Hoche have shown the existence of many association fibres of limited extent in the direct cerebellar columns and in the columns of Gowers, and, therefore, it seems evident that every column of the cord contains fibres which are passing in both directions.

If we study carefully the result of degenerative processes following transverse lesions, it becomes evident that the degeneration, though very intense near the lesion, becomes very much less so as we get further from the lesion, no matter at what level the latter may lie. It is thus proven that the number of short tracts in the cord is far greater than the number of long tracts, and inasmuch as these short tracts can only be nerve roots, or else tracts of association, it is evident that there are but few very long fibres extending through the cord to the brain.

When the long tracts are carefully studied by the process of Marchi, it again becomes evident that the number of really long continuous fibres is relatively small. The long motor tracts are well established, but the sensory tracts are not so clearly defined. It has been the fault of many observers, who have studied ascending degenerations, to have described these degenerations only as high as the fourth or third cervical segment. This is probably owing to the fact that at autopsies the first, second and third cervical segments of the cord are commonly divided obliquely in getting out the brain, but in the cases in which this error has been avoided, and sections have been made of the second and first cervical segments, it is quite remarkable to discover how very much the degeneration in the so-called long ascending columns, which is very extensive in the fifth and fourth cervical segments, is reduced in size at the first cervical segment, a fact which proves that many of these long fibres supposed to reach the brain really terminate in the spinal cord itself.

Furthermore, when the oblongatal and pontine prolongations of these ascending tracts are investigated, it has been found that none of them are actually continuous with the fibres of the crura cerebri. In other words that there is no tract passing directly from the cord to the brain cortex. Thus, the ascending fibres of the posterior columns all terminate in the nuclei graciles or cuneati, whence new fibres pass onward, either to the cerebellum or to the interolivary tracts. The fibres of the direct cerebellar column, which are considerably reduced in number before entering the restiform body, pass directly to the cerebellum. Edinger and Hoche have shown recently that the fibres of the ascending anterolateral tract or column of Gowers are also considerably reduced in number in the oblongata, and pass exclusively to the cerebellum through the superior peduncle, after traversing the formatio reticularis of the pons. While many fibres that lie in the anterolateral columns of the cord enter the formatio reticularis of the oblongata, none are known to pass continuously through the formatio reticularis, but all are supposed to terminate at various levels within the oblongata, pons, or tegmentum of the crura.

It must, therefore, be admitted that we do not know of any continuous sensory tract from the spinal cord to the brain, and even if the lemniscus is continuous from the oblongata to the cortex (and it must be remembered that some authorities deny this fact, and state that all the fibres of the lemniscus terminate in the corpora quadrigemina, or in the optic thalamus) it cannot be stated that the lemniscus forms a direct sensory tract from the cord to the brain, since it begins in the nuclei graciles and cuneati of the oblongata. These facts then compel us to believe that sensory impressions are conveyed through the central nervous system by means of short tracts, interrupted in their course, and not by long continuous fibres.

If we approach the subject from another standpoint, the same conclusion is forced upon us. The effect of an ordinary sensation in any part of the body, especially if that sensation be of sufficient importance to give rise to pain, is not merely a conscious perception. The primary effect is a multitude of reflex actions, entirely below the sphere of consciousness. Thus an ordinary painful impression will result in the retraction of the limb that is irritated; in the setting up of vasomotor and trophic reflex actions, or, if the irritation is kept up, in a general sense of uneasiness throughout the body, and even complex reflex actions to remove the source of pain; not to mention the quickening of respiration, the facial expression of pain, and automatic exclamations. All of these may be produced in an animal whose cortex is removed, or in a man when asleep or under the influence of ether. It is, therefore, evident that a sensory impression, if of sufficient severity, or if continuous, may practically throw into activity almost the entire subcortical nervous system. In other words, that a single sensory impression may be primarily distributed to all the motor centres through the entire length of the spinal cord and of the cerebral axis, in addition to its awakening cortical activity. This effect could not be attained were the sensory tracts from anyone region of the body continuous tracts to the cortex. It could only be attained by a mechanism which would provide for the termination of the single sensory tract at all levels of the cord, or by mechanism which would provide for the dissemination of a single sensation by means of short association tracts throughout all these levels, and as we have already seen from the study of anatomy and pathology, it is the latter provision which seems probable.

There is one other possibility of sensory transmission which need detain us but a moment. It is known that in the posterior horns of the cord a peculiar substance, the substantia gelatinosa, is present, which is also found at the termination of the descending branch of the fifth nerve in its entire extent, and hence has been thought to have a necessary connection with the reception of sensations. Golgi's researches have shown that this tissue consists of a very fine network of nerves and fibres, consisting probably of the terminal brushes of the nerves of sensation. This substance, therefore, has an important function in the reception of sensation. It may be stated, however, that it cannot have any function in the transmission of sensations continuously to the brain; it cannot be looked upon as a long sensory tract. The reason for this lies in its extent at various levels of the cord. If it were a long tract of transmission, we should expect its size to increase steadily from below upward, each succeeding higher level transmitting larger numbers of impulses than those below it. But as a matter of fact, the substantia gelatinosa is more developed in the lumbar region relatively to the size of the cord than it is in the dorsal, or even cervical region; and it is reduced to a very small extent in the upper cervical segment. This hypothesis may, therefore, be discarded.

It seems, therefore, evident that the transmission of sensations through the cord must have for an anatomical basis a series of short neurons, each conveying the impulse from the level of its reception in the cord to a level somewhat higher, where again it is transferred to another neuron, and so on, and on, till it reaches the cortex. This hypothesis is substantiated by the researches of Ramon y Cajal and Lenhossék. They have shown that the majority of the neurons of the cord are short in extent; have numerous collateral off-shoots, so that an impulse starting from any one neuron is sent upward and downward to other levels, but is not sent to any very great distance. In a word, the structure of the cord is such as to secure a wide dissemination of single impressions to very many levels.

It only requires a brief reference to the known structure of the cortex to substantiate the assertion that here also there is a perfectly homologous arrangement of sensory terminations. The sensory expansions in the cortex are of the widest kind, securing a large diffusion of impulses to an extensive region. In fact, the great rarity of complete anesthesia in one limb from cortical lesions is a striking proof that sensations are diffused over the cortical regions, and cannot be as accurately or closely located in certain limited areas as motor centers are. This, also, is entirely in accordance with the object of sensation, which is to awaken a variety of responses, including conscious perceptions, voluntary acts, comparison of associated impressions, and a train of thought. Is it not, therefore, evident that in the transmission of sensation through the spinal cord, cerebral axis and brain, we have to consider the tracts as different in their structure from those conveying motor impulses, and as consisting of a series of short neurons, closely connected, but with very numerous and very widespread connections? Is it not probable that the result of this arrangement is to secure a diffusion of single sensations to various reflex, vasomotor, trophic and automatic mechanisms, as well as to the organ of conscious perception? And is it not also evident that this view of sensory diffusion explains the apparent inconsistency at present prevailing between the clinical symptoms observed in Brown-Sequard's paralysis and the pathological degenerations occurring in that disease, viz.: the anæsthesia opposite to the lesion, and the ascending degenerations on the side of the lesion? The diffused sensations traverse the uninjured half of the cord, being obstructed at the lesion, and lead to a confusion of impressions and to hallucinatory mistakes of conscious perception. The same thing is observed in the symptom of allochiria.

It seems to me, therefore, that it is useless to search for sensory tracts in the cord as units, or for long sensory columns like the pyramidal motor tracts. The only long columns conducting upward are those related to the cerebellum, and conveying the very numerous sensations necessary for its guidance in maintaining equilibrium and balance; sensations which are necessarily so numerous, and come simultaneously from so many sources that it requires a large central organ to receive and combine them all, with definite tracts leading to this organ.

I should, therefore, conclude that in the conduction of sensory impulses to the brain cortex a large number of different neurons are concerned, which are located in the gray matter and in all the various columns of the spinal cord, and that there are no true sensory columns or long continuous sensory tracts between the spinal cord and the cerebral cortex.